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MICROSCOPIC RESEARCHES

*To Prof: R. Livingston
with the author's
respects.*

ON THE

BLACK VOMIT OF YELLOW FEVER.

BY

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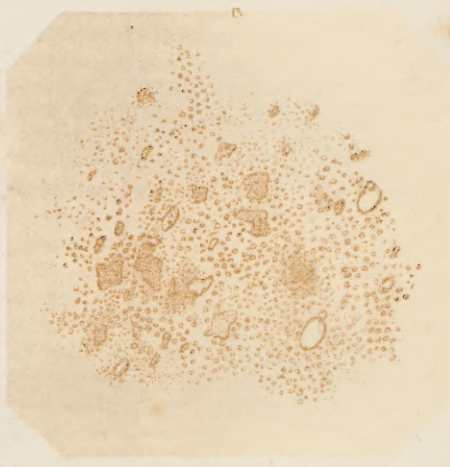
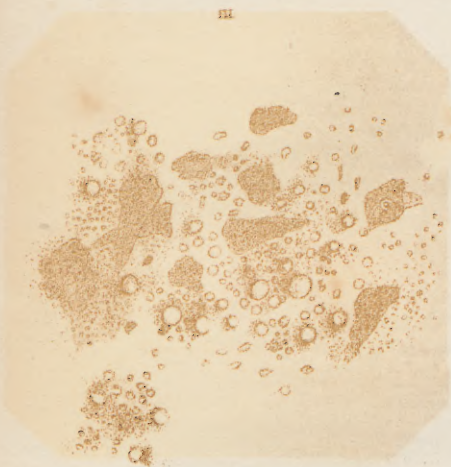
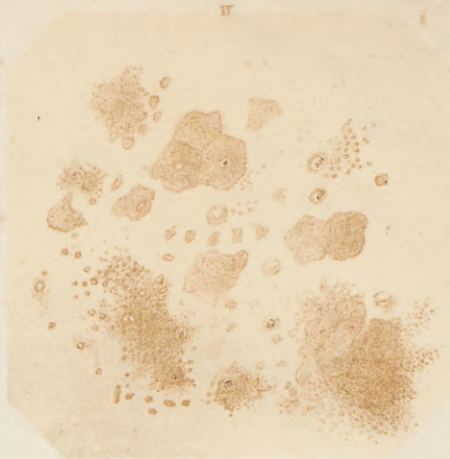
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EXPLANATION OF THE PLATE.

THE microscopic appearances of artificial and true Black Vomit, fresh and putrescent, from the stomach and by stools, under magnifying power of 400 diameters.

Fig. 1. Represents the coagula as they appear before manipulation. Shreds of inspissated mucus entangling epithelia, granules and blood discs tinged with hematine.

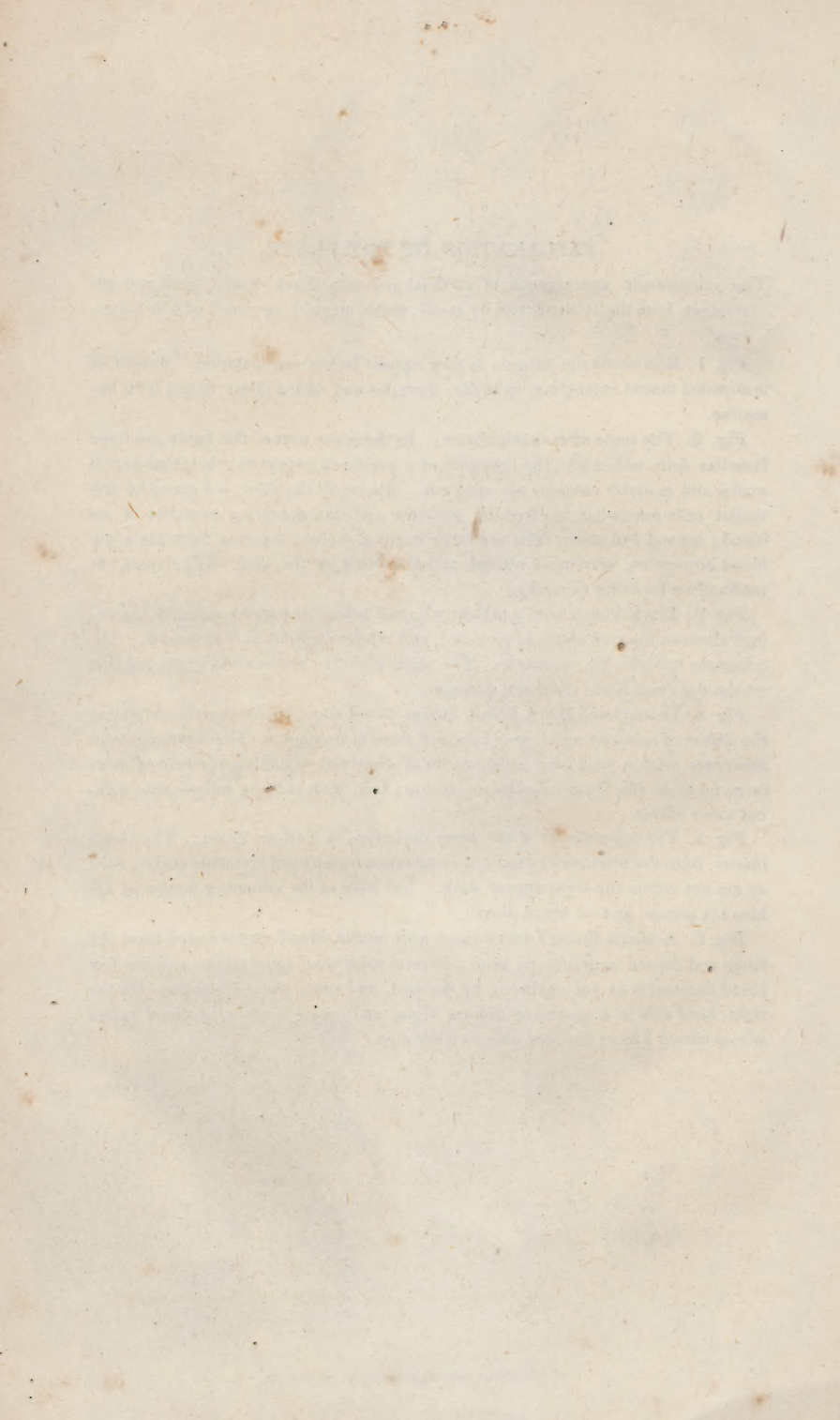
Fig. 2. The same after manipulation. In the upper part of this figure are three lamellar cells, united like the hexagons of a tessellated pavement; their transparent nuclei and granular contents are apparent. Below, to the right, is a group of epithelial cells somewhat masked by granules and the colouring hematine of the blood; around and above them are large mucus globules; between these are a few blood corpuscles, very much altered and shrivelled by the acid. [Examined immediately after being ejected.]

Fig. 3. Black Vomit from a patient who had taken lime water and milk, examined about an hour after it was procured, and represented just as it appeared. The columnar epithelia are numerous. The milk globules are seen in great numbers amidst deformed blood discs and granules.

Fig. 4. Decomposed Black Vomit, broken down into a granular mass containing the debris of epithelial cells, seen here and there in fragments. The figure contains numerous minute oval corpuscles (nuclei of dissolved epithelia), and four or more large fungi of the *Torula* species, of an oval form with budding cells—some without these offsets.

Fig. 5. The appearances of the pasty dejections in Yellow Fever. The bluish mucus from the intestines containing numberless transparent epithelial scales, such as are not within the focus appear dark. But little of the colouring matter of the blood is present and no blood discs.

Fig. 6. Artificial Black Vomit formed with mucus, blood expectorated from the lungs and diluted hydrochloric acid. Several spheroidal cells are seen, some few blood corpuscles as yet unaltered by the acid, and some mucus globules. On the right hand side is a species of filiform algæ, and below a series of ovoid bodies whose nature I have not been able to determine.



MICROSCOPICAL RESEARCHES ON THE BLACK VOMIT OF YELLOW FEVER.

It would be superfluous to preface the remarks which are to follow with any studied comment upon the advantages of the microscope in determining the nature of morbid products, since it is acknowledged to be the best means in our power of arriving at a determinate result. I take it that this is particularly the case respecting the peculiar and almost pathognomonic ejections in Yellow Fever designated *Black Vomit*, for though early surmised that they were chiefly composed of blood in a vitiated condition, or specially acted on by the gastric juice, yet this opinion was entertained only as the most probable hypothesis, and was itself the source of some of the varied and daily-extending speculations concerning the subject. Chemical examination may detect the properties of the vomit as acid or alkaline, the presence of mucus, even iron and all the other elements of the blood, but microscopical analysis at once enables us to view these in their material relations or forms as globules, discs, epithelial cells, etc., which places the essential character of the product before us in an unequivocal light.

The researches which I made on this subject in 1849, and which were briefly recorded in a previous number of this Journal, both by Dr. Hayne and myself, satisfied me fully as to the character of Black Vomit, but the recurrence of the epidemic last summer furnished me an opportunity of repeating these inquiries on a much more extensive scale, having examined some forty samples under varied circumstances in and out of the stomach and intestines, in the fresh and putrescent conditions, and under the influence of certain reagents. For these facilities I am indebted to the complacency of friends, whose names I shall mention as we proceed.

The diversity of colour in the vomit is sufficiently striking to be particularly mentioned. Though generally reddish-black, it often presented a brown, reddish or blackish-brown, and sometimes claret colour. From a patient whom I saw with Dr. Hayne, which patient ejected large quantities and ultimately recovered, the liquid was bright red, recognizable as pure blood with black flocculi in the sediment, while one sample brought me by Dr. Pettigrew was of chocolate colour with a brownish residuum. Some obtained from my own patients resembled a strong infusion of senna, holding in suspension the ordinary

black clots and granules; others, even in a state of rest, were more like a solution of bismuth and Indian ink; some again were perfectly black, and these were such as I procured from the stomach most generally. The intensity of colour is much influenced by rest or motion, as it acquires a denser shade whenever the fluid is agitated, and the granules, flocculi and coagula are made to float; on the contrary, these particles, when the liquid is at rest, settle at the bottom, being specifically heavier than the former, leaving the supernatant liquid comparatively clear, sometimes transparent as serum. This is not always the case, however, as I have seen the solid portions in the same sample equally divided into such as formed a sediment, and such as floated on the surface. The quantity which may be produced and ejected in a given time materially affects the colour, this being of a brighter red whenever the fluid is thrown up in abundance until it frequently amounts to pure blood; whereas, the dark black and granular aspect with the coffee-grounds sediment, described as characteristic of Black Vomit, belongs particularly to the smaller portions which are early vomited—a circumstance which claims special attention, as it will be found to account for the difficulty experienced in producing these exact particles in the artificial trials which we made with blood and acids, as well as for the occurrence of pure blood of the scarlet hue in many instances of hematemesis. It is proper to remark that there is rarely, if ever, any greenish or yellowish tinge observable, no evidence whatsoever of the presence of bile; and I believe this is the concurrent testimony of all who have taken the trouble to repeat Dr. Warren's tests. The highest authorities agree as to the absence of bile; I do not mean to imply that bile may not be found sometimes accidentally mixed with the vomit, but it is not an ingredient; in other words, Black Vomit is not vitiated bile as was formerly believed. Dr. T. Y. Simons,* whose opinions on this subject are worthy of special attention, has always, as he tells us, been able to discriminate between the true *black* ejections of Yellow Fever, and the vitiated *bilious* fluids thrown up in other diseases.

I deem it important to note these differences of colour, as I find they depend upon admixture in varied proportions of the constituent parts, and are all essentially the same morbid product, as was shown by their microscopical characters.

The specific gravity, water being reckoned as 1000, I find to vary from 1010 to 1027. When kept until decomposition begun, and bub-

* Essay on the Yellow Fever, etc., read before the South Carolina Medical Association. 1851.

bles of air and gases were produced, this changed very much, being sometimes as low as 0986 or 0962. The decanted liquid without the solid parts gave 1000 to 1015. That which I gave to Prof. Hume, for chemical examination, was remarkably black, and he informs me has a specific gravity as high as 1032.

In every instance the vomit was decidedly acid, turning litmus paper red, and this acid has been detected as free muriatic, which is present in gastric juice according to recent investigation. The acid property of the vomit is most remarkable, for I made constant inquiries of those suffering from this symptom, and they frequently complained of an acid burning sensation in the throat and pit of the stomach, referable doubtless to its presence. The elimination of this acid seems to be without restriction, for in one case basin full after basin full was thrown up presenting the same reaction. Such rapid productions of acid, as I have sometimes noticed, appear to me to be a perverted condition of the functions of the stomach. The slightest aberration of the healthy action of this organ alters the state of the gastric secretions, and in this disease I have every reason to believe the change consists in a preternatural increase of acid. All degrees of acidity are recognizable to an extent sometimes to produce remarkable effervescence upon the addition of a carbonate, though this does not occur when little acid is present. The vomit appears tasteless from what experimenters say, its acidity being all that is recognizable. Dr. F. M. Robertson,* during an epidemic of Yellow Fever in Augusta, having tasted some, could not detect any trace of bile, but perceived the acid very readily, finding it in other respects not only insipid, but inodorous.

From the danger accompanying the supervention of Black Vomit during an attack of this fever, it is no matter of wonder that it should have excited inquiry as to its real nature, but when this is so easily determined, it does indeed appear surprising to witness the diversified and painstaking theories respecting it. Had the smallest particle of this black liquid been conveyed to the stage of the microscope years ago when the whole country disputed its character, speculating and theorizing ingeniously about it, it would have been found to be nothing more nor less than blood, mucus and epithelia, disturbed by the action of some reagent, and in forms as tangible, if I may so speak, to the compressorium and other instruments in ordinary use, as these organic products are in any other conditions. This evidence I shall endeavour now to give, as the explanation of the figures in the plate forms the principal object of my present design.

* Medical Examiner, vol. 2d, p. 661. 1838.

The filtered liquid I have always found perfectly transparent, with the exception of such amorphous granules as sometimes swim through serum itself. Its specific gravity in this clear and undisturbed state has already been mentioned. Selecting some of the most minute specks from the coffee-grounds sediment, they presented under the microscope every resemblance to coagulated blood, appearing as so many dense opaque masses tinged darkly with hematine. Here and there were congeries of granules invested with the same colouring ingredient, and this entire confused mass, from which at first nothing could be deduced but that it was impregnated with the colouring matter of blood, I have represented just as it appeared in Fig 1 of the plate accompanying this paper. When rendered fit for study by the manipulations necessary to disintegrate and wash down the several objects composing these masses, I obtained the distinct view in Fig. 2. Small portions, rendered less opaque by this process, were found to consist of shreds or beds of mucus entangling numerous scales, granules and some blood discs; and as they floated over the field of vision, the tenacity with which the flocculi of Black Vomit preserve their colour and form seemed easily explained, the blood being so enclosed among the epithelial cells and mucus as not to be easily dissolved, or its fibrine washed white even in samples kept for a length of time.

It will not be unimportant to allude specially to these cells always found in Black Vomit, as it must be remembered that they indicate with peculiar precision the particular parts of the surface of the great mucous tract whence such an effusion emanates. I should state at once that I have detected all the varieties of epithelial cells except the ciliated. The *scaly*, *columnar* and *spheroidal*, have at different times been plainly made out with their nuclei and nucleoli, but in very different proportions—the scaly or lamellar cells being always most numerous. Many of these latter are seen as perfect in shape as when artificially removed from the mucous surfaces of the throat, gullet or mouth, and frequently united by an adhesive intercellular matter in the order of the hexagons of a tessellated pavement, some presenting at their centres accurately defined nuclei, which the addition of a little diluted acetic acid rendered even more apparent. These are evidently shed from the mucous lining of the œsophagus, pharynx, back part of the fauces and mouth during the act of vomiting, and are stretched along so extensive a surface as at once to account for their frequency. The abrasion which these surfaces sustain results from the acidity of the matters vomited. But if carefully examined there is no sample which will not disclose the presence of the columnar epithelium of the gastric

membrane. In Fig. 2, these may be seen in a somewhat obscure pile of cells, on the right-hand side, covered over with granules and surrounded by a few mucus globules and blood discs. This variety of which I speak was beautifully revealed in what Dr. Hayne procured from a patient in the Roper Hospital, who had just ejected an ounce or two after having taken lime water and milk. We at once detected the milk globules rolling along in large numbers, colourless and of various sizes. On this occasion the caudated cells were seen without any difficulty, and without requiring any preparation; some of these again were recognized as nucleolated cells, the nuclei being somewhat oval though not materially different from those of the polygonal cells: (Fig. 3,) spheroidal epithelia were very scarce and only met with on two or three occasions, as they were probably very soon flattened into polyhedral figures, but they may be seen whenever the mucous secretions predominate. These cells are derived from the mucous follicles and salivary ducts, most likely from the former, as I have not frequently detected them in saliva. All contain a fine granular matter, and were always more or less stained with hematine, the application of diluted muriatic acid rendering them yet more distinct, and cleansing them of extraneous particles.

An inspissated viscid form of mucus, if such I must consider it, of remarkable tenacity, constitutes a conspicuous feature of Black Vomit. In my opinion it should be taken as decided evidence of diseased action of the stomach, for it is improbable that viscid mucus is ever normally produced on healthy mucous tracts. Condensed into glutinous masses, as it were by the action of the acid secretions, this substance was filled with granules, and the relics of epithelia, entangled with which it in a measure owed its consistency, and but for having imbibed a certain amount of blood, exactly resembled *fluor albus*, as seen with the microscope. The mucus globules bear no relation in point of numbers to the masses of this albuminoid ingredient, they were few and scattered about the field, as may be seen in the plate; presenting as they do generally a well defined outline and a granular surface, these were conspicuously more translucent, and their contour less distinct though the granular appearance was sufficiently evident in most cases. They were distended by the endosmotic imbibition of the aqueous solutions in which they appear. A strong mixture of salt and water disturbed their transparency and diminished their size by corrugating them. The viscid mass is not composed of mucus globules, for where it exists in greatest abundance, in the stools for example, these were wholly absent. When compressed into a thin layer, this mucoid mass

appeared as a soft, homogeneous, granular and filamentous structure, the shreds of which matted together in an irregular manner somewhat resembled fibrine as it is seen to coagulate when microscopically inspected, or perhaps like albumen coagulated by acid.

Blood, in a broken down and altered condition, is met with invariably in abundance; indeed, it is this which constitutes black vomit *par excellence*. Every object under the microscope is intensely coloured by it, as a large proportion of hematine appears to be in complete dissolution. It need hardly be remarked, that the blood corpuscles are entirely separated from each other, and never seen in rolls or piles, and equally changed in their physical nature. We see no discs or but few turning edgeways while in motion. The vast majority are entirely dissolved, a granular detritus being all that remains even in the freshest condition. Some again are spheroidal, distended, or otherwise misshapen, most generally corrugated, measuring 1-3000th of an inch, undergoing exactly the same modifications as we produce at will by treating them with acetic, nitric, hydrochloric acids or concentrated saline solutions.

Desirous of repeating the observations made in 1849, upon black vomit from the stomach itself, I obtained again several specimens, for some of which I must acknowledge my indebtedness to Dr. Ford Prioleau, Physician of the Alms House, who furnished me also with a portion of intestine containing the black, pasty matter so frequently voided during intestinal hemorrhages, and almost always encountered in the lower part of the alimentary canal in yellow fever. The liquid contained in the stomach was blacker than usual, but the appearances were the same as have already been described, with the exception of pavement epithelia, none of which exist in the stomach.

The pasty, black intestinal matter is a muco-granular substance, containing a multiplicity of lacerated cells, but no blood corpuscles, the dark bluish mucous colour being hardly obscured by any hematine, (Fig. 5,) the blood having apparently undergone a kind of digestion in its passage through the intestines. This is so different in its microscopical character from black vomit from the stomach, that any one may readily distinguish them. But that formed higher up in the canal has the ordinary appearance under magnifying power.

Dr. Rhees'* remark, that black vomit contains animalculæ, has been frequently repeated, and even recently again by J. Manley,† and they are very generally believed to constitute a feature in its history. Upon Dr. Rhees' authority I once supposed I had discovered them, and stated

* Philadelphia Journal of Med. and Phys. Sciences, vol ii., p. 23.

† London Lancet, January, 1853, p. 20.

that, as an organic product, it would, in the putrescent state, develop *infusoria*, though, in recent samples of the ejecta, I never detected spontaneous evolutions of this kind. On this subject I have experimented with care, and if, by *animalculæ*, we are to understand the initiatory forms of *animal* cell life, as they are recognized in the familiar varieties of Polygastrica and Rotifera, I say, without hesitancy, that such were never to be seen, either in fresh or putrescent specimens of the vomit. Dr. Rhees' experiments were made with the solar microscope, an instrument certainly not adapted for such investigations as these. Without incurring the charge of presumption, I may venture to doubt the accuracy of such observations, as my own inquiries, on quite a large scale, have not suffered me to corroborate. If infusoria were present, we could hardly fail to encounter them, for, whoever has watched the development of the simplest monad, is aware that they are propagated with such magical rapidity, that where one is discovered, countless numbers are soon found to follow in its suite.

Having kept some bottles of this liquid for several weeks during the warmest days of summer, and having recently examined what has been handed me by Dr. J. Holmes, which he obtained five months since, I have not been able to discover, with a magnifying power of four hundred diameters, any living or dead infusoria. I have searched in vain for the monad species which are so often met with in impure organic matters, moving by vibratory cilia, but these, nor none of the other varieties, were ever present; not that their existence in the vomit would have been of any importance, however, in adding to our knowledge of its nature, nor of any greater significance than when they are evolved from decomposed organic substances, but that it would have furnished me the privilege of verifying what has so long been accredited. The fourth figure in the plate represents the black vomit as it appeared while decomposing. Here the entire fabric is resolved into a fine granular liquor, containing the debris of epithelial cells, broken into irregular pieces, with the cell walls of partly dissolved blood discs in extremely small numbers, the mucous masses having also been completely dissolved. These examinations of the putrescent fluid have afforded me an opportunity of witnessing the development and mode of growth of a fungous Protophyte that I exhibited to my friend Dr. Williman, and which very much resembles the *Torula cerevesii*, if it be not identical, the only difference being the constant absence of nuclear cells at all periods of its development and growth, a circumstance which may render it of some physiological import in regard to cell formation. Developed as it is in decaying organic matter, under a freer elimination of

carbonic acid and ammonia than atmospheric moisture would furnish, it is most favourably situated for the manifestation of its peculiar vegetative tendency. This species of *Torula* consists of oval cells, measuring the 1-1608th of an inch in the longer diameter, and 1-2050th in their short, being about the size of the smaller elliptical red particles in the blood of birds. They are spheroidal, not flat, and perfectly pellucid, with no granular contents. In a few hours they put forth little cellular projections, in the form of buds, from one or both ends of their elliptical margin, which continue to grow until they are as large as the parent cell, when the process is probably again repeated in the offsets, until a progeny of many beaded cells would indicate a more perfect if not complete development. However, I have not seen this variety of *Torula* reach more than two buds when the cells of unequal size sometimes became detached, as separate individuals, before they seemed to have attained their full growth; after which, a new process of gemmation commences. It is in this arrested stage of development—as a cell with one or two buds—in which I invariably discovered the *Torula* in the black vomit. Fig. 4.

It is not only interesting to notice this evolution of cells from the parent or primordial cell, but instructive to observe that it does not depend upon a nucleus. The mode in which this gemmiparous birth occurred I examined patiently, and endeavoured to advance it onwards to the development of a series of cells, by placing it in conditions most favourable to this end, but in this I was frustrated, through the influence of circumstances apparently beyond my control, the ferment-cells seeming to become blighted as soon as they had put out one or two buds. This, however, may be its ultimate or full development as one of the varieties of *Torula* expressive of the simplest form of vegetation.

The means by which the reproduction of this fungi is effected, does not consist in a segmentation of the cell, as is observed in development by fissiparity, where the bipartite division extends through the cell to the nucleus itself, which thus becomes appropriated to two cells of equal size, but, in the process as here seen, the cell shoots out into buds or vesicles, which, in their earliest condition, consist in a diverticulum from or bulging out of the cell-wall, so that, at first, the cavities of both bud and parent-cell communicate through a constricted portion of the common envelope, which becomes more and more narrow as the bud is developed, until the passage is obliterated. The new-formed vesicle then expands until it gradually acquires the dimensions of the dependent cell.

A close analysis of the phenomenon of gemmation, as it here occur-

red, justifies the opinion as to the apparent identity of the two plans of development by *fissure* and *gemmation*, the difference being only one of degree. Indeed, in both instances, the initiatory process is the same: a constriction of the cell-wall, by which it is ultimately divided either into two equal halves, by what is called *fissure*, or two very dissimilar cells in point of size, which is by *gemmation*.

It is questionable, in my opinion, whether there be any direct dependence, as cause and effect, between the evolution of this fungus and the phenomenon of fermentation. That such vegetable growths find their proper beds in organic matters in a state of decomposition is certain, for we do not detect them about fresh products; but the development of the fungus is not the cause of the decomposition, for, in the case which I am now detailing, there seemed to me to be positive proof that there was no relation between the number of *Torulæ* which were developed, and the degree or continuance of putrescence. On the contrary, when the decaying matter had lain by for some time, there was no corresponding increase in the size and propagation of these cells, even when a kind of fermentation, with generation of offensive gases, was produced; nor can we attribute this to an arrest of the life of the cell from these very emanations, when it is remembered how tenacious of vitality is this class of protophytes, under all changes, even when undergoing complete desiccation.

The decomposed vomit contained nothing else worthy of notice, unless it be certain oval corpuscles, which I at first took for young ferment-cells, until chemical tests showed them to be the undissolved nuclei of epithelial scales. No part of these researches has presented more difficulty than the determination of the nature of these corpuscles. They were insoluble and unchanged in acetic acid, showing that they were not blood corpuscles; nor are they to be confounded with the sporules of the *Torula*, which were larger, and disfigured by concentrated acids. I also supposed that they were some small variety of *Alga*, but believe them now to be the nuclei of columnar epithelia from the stomach.

Cells certainly exhibit a variable constitution in their healthy and diseased development, concerning which we know as yet but little. Their nuclei in both physiological and pathological conditions are insoluble in acetic acid, so slowly disappearing that they remain for hours and days unaltered. The cell-wall in healthy epithelia is, on the contrary, readily dissolved, except where it becomes corneous; while in diseased or abnormal cells—after these have attained their full development—acetic acid has hardly any influence upon the envelop. Again, there is no question of the fact that a shedding and renovation of colum-

nar epithelia is constantly taking place in health : as for example during digestion ; and a provision is made for their reproduction by the presence, as Dr. Goodsir believes, of persistent and proligerous nuclei in the primary or basement membrane beneath the epithelium.

What occurs therefore as a normal function, or as the result of accidental abrasion in health, is observed also in disease ; for the mucous membrane of the stomach in yellow fever often presents a thickening, accompanied by a preternatural development of young epithelial cells, most of which are immediately thrown off as they are formed, together with many proligerous nuclei ; which *moulting*, as it were, of the mucous surface lays bare the smaller capillaries and gives rise to hemorrhage, when the process of repair is again set up and numerous abnormal scales are again produced.

Applying these facts to the solution of the difficulty, I am disposed to regard the oval bodies represented in the several figures of the plate, as the reproductive nuclei of epithelia. Like ordinary nuclei, these corpuscles were insoluble in acetic acid, and were often associated with cells, which resisted the action of the same reagent ; which I regarded as evidence of their pathological state. In numbers, size and form they closely resembled the nucleoli and nuclei of epidermal cells as these are renewed upon vesicated surfaces in the progress of healing.

The record of the results of, and inferences deduced from, researches continued through two epidemics, may not be entirely devoid of interest, if I may have conveyed definite or precise knowledge respecting black vomit. Early in 1740, Warren certainly speaks of the "fixed and unhappy prejudice" that yellow fever is a "purely bilious affection," and states his conviction that the matters ejected contained no bile, and that cloths are tinged with a deep purple or blood-red when dipped into the vomit. The same opinion was promulgated by Dr. Pym, and seems to have been the one expressed by Hunter, Pringle, Sir Gilbert Blane, and many others ; but suffer me to ask, whether it has been received in any other light than a plausible conjecture ? Do we not find, in 1844, Dr. Nott, of Mobile, endeavouring to maintain the accuracy of Pym's statements by experiments which have not obtained any more general sanction, nor even that attention which they deserve ? I am cognizant of the fact, that vague and purely hypothetical notions, even while I write, are still entertained on a subject certainly of sufficient importance to excuse my trespassing at this length upon the reader. It is true, the antiquated opinion that this morbid ejection consists in sphacelated exfoliations from the stomach, macerating in the fluids and mingled with the mucus of that viscus, has fallen into merited oblivion ; yet, if we

analyze the arguments of the present day, the equally ancient supposition of its being vitiated or black bile is the only choice of opinions left us, and must become more virtually prevalent than they even suppose who rest their refutation of all these views upon the erroneous assertion of its presence in the vessels of the stomach. Drs. Physick and Cathrall detected a black, grumous matter in the vessels of the membrane of the stomach, but what does that prove? that it is a secretion? Certainly not. Dr. S. H. Dickson has seen the same, as he informed us in his valuable lectures, which it was my privilege to have heard during the past winter; and it is only my conviction of the accuracy of my own observations, made from twenty-eight or nine autopsies performed by Dr. Hayne, which permits me, while presently giving a different interpretation to these facts, to differ from such high authorities. The same assertion has led to the rejection of the hypothesis, that black vomit is a chemical change wrought in the blood by the action of the gastric juice, suggesting, in its stead, the idea of a secretion dependent on an altered condition of the blood. That the blood is perverted in this as in many other diseases, such as the low forms of typhus or typhoid fevers, in scurvy, purpura hemorrhagica, and the like, will scarcely be denied. I myself have found it rather fluid, and though the blood corpuscles are unaltered in shape or size, they appear to me to be less firmly connected in rolls or piles, many swimming detached in the serum; that they are readily disintegrated from some change in their envelopes, I am inclined to believe; and in this manner I suppose the hematine is dissolved, and may permeate the vessels. But the blood under these morbid states, is not peculiar to yellow fever, and does not itself constitute black vomit; nor are such changes essentially necessary for its production, however much they may favour it, as true black vomit may and does occur independently of similar modifications. Thus Dr. Dickson has met with analogous ejections in pregnant women, in gastritis, in varioloid, and with a substance similar to black vomit in the excretion from the bladder in a renal affection accompanied with bloody urine. Dr. P. G. Prioleau related its spontaneous occurrence in a perfectly healthy youth after excessive fatigue, and I would add that I have recently seen, in my own person, the coffee-grounds specks well marked during dyspeptic vomiting, after sudden and severe retching, accompanied with intense acidity. Such occurrences are sufficient to prove that this symptom is not a pathognomonic sign of yellow fever, and that it is wholly independent of any radical change in the mass of the blood, though, according to the specific notions entertained, they

would seem singularly to embarrass a question which I think admits of easy solution.

We are indebted to Dr. Carswell, in his valuable division of melanosis into true and spurious, for the first information respecting the chemical action of acids on the blood in the vessels; and to Drs. Stevens and Babington, for accounting in this manner for black vomit. Whenever an acid mingles with blood, its red colour is immediately altered from varied shades of brown to deep black, according to the amount of acid. A current of carbonic acid passed through blood, darkens it; and by an ingenious application of this fact, the presence of carbonic acid is supposed to give the dark hue to venous blood, while its abstraction by oxygen, combined with the saline matters contained in the vital fluid, returns this to its scarlet colour. By carefully adjusted proportions of any acid, it is, therefore, possible to obtain all gradations of shades in the blood; but what is still more satisfactory in the experiment, the blood immediately curdles, as it were, into little flocculi, hardly dissimilar from those of the black vomit. It is difficult always to produce the coffee-grounds sediment, since it is impossible to apportion certain particles of blood to those of the acid, as when it oozes in disease from the tissues. I have, however, been able to produce artificial black vomit so perfectly similar in this respect to that fluid itself, that their identity was at once apparent. During my attendance on a case of hæmoptysis, in which slight mouthfuls of blood were coughed up at a time, I obtained about a drachm, which was added to about six ounces of water, with a few drops of hydrochloric acid, which, upon being well shaken, developed all the characteristics of black vomit. It was allowed to rest, when the black flocculi formed the usual sediment. The production, in this manner, of a fluid, the properties, colour and appearances of which are in so remarkable a manner similar to black vomit, certainly constitutes a most ingenious experiment—one, indeed, so far as ocular demonstration of a general character is concerned, which is perfectly conclusive; and yet, it must be confessed, that it has been disputed whether it should be regarded as at all conclusive; and some have supposed that the difference between this and true black vomit can be always pointed out. For this ingenious experiment, I believe we are indebted to Dr. T. Y. Simons, who, in 1833, while Professor of the Practice of Medicine, was in the habit of performing it before the class in attendance. And this has been repeated again by Dr. Nott in 1844. Now, if the microscope is necessary to determine the real character of black vomit, it becomes of equal importance in

testing the appearances of the artificial fluid; and experiments of this kind I have also made as the complement to these researches.

On examining the artificial specimen with the microscope, the analogy was so striking, that I have thought proper to represent it in (Fig. 6.) I found blood discs as yet unaltered by the chemical action of the acid, but most of them were entirely dissolved; large masses of mucus, with mucus globules, and epithelial scales from the mouth and throat were present, with a few spheroidal ones, though I detected none of the ciliated variety from the bronchial tubes; the blood was so dissolved as to colour the mass as usual, and the entire aspect was, in every particular, so completely analogous to black vomit, that an observer must inevitably be deceived as to whether he is examining the true or artificial product, for they are microscopically identical.

In presence, then, of such facts, there is room for no reasonable doubt as to the character of the influence which the gastric juice, always more or less acid in this disease, exerts on the blood effused into the stomach. Reference to special pathology and pathological anatomy, justifies these experiments, if, indeed, additional proof can be required.

The differential diagnosis between hæmoptysis and hæmatemesis, rests in part upon the colour of the blood which is voided. It is known to be much darker, indeed nearly black, when emanating from the stomach; and so frequently is this change of colour observable, that it has been supposed to depend upon the particular source whence the blood is derived in the two cases—referred to a venous origin in the one instance, to an arterial in the other. But this circumstance is due in reality to the admixture of the blood, on the one hand with oxygen in the lungs, on the other with the hydrochloric acid of the gastric secretions. If the fluid thrown up in hæmatemesis has sometimes all the properties of pure blood, this is owing to its pouring out more rapidly than it can be acted on by the acid present in the stomach. The same occurs in yellow fever; for I have seen, as has been stated, nearly pure blood ejected from the stomach in this disease. In the same manner we must explain the supervention of a like phenomenon, when the subjects of it are otherwise in perfect health, as, for example, during gestation, in dyspepsia, etc.; for, whenever there is a predominance of acid, as in pregnancy and dyspepsia, the same black substance may be voided; and this, again, is seen in certain instances in renal affections, the blood becoming ultimately mixed with the acid mucus of the bladder. There is such a thing, we learn from Carswell's researches, as spurious melanosis, which again is blood subjected to similar chemical changes; and *melæna*, we are

told, deserves no longer to be regarded as a separate disease. But Drs. Physick and Cathrall argued that black vomit is found in the vessels of the mucous membrane of the stomach, where, by conjecture, it is elaborated, and may be expressed from them; consequently, before it transudes the coats of that organ. Now, I am satisfied that this is unquestionably a cadaveric alteration; for in the necropsies which we made in 1849 (my friend, Dr. Hayne, will corroborate the statement), the bodies were opened immediately after death,* while they were yet warm, and we never discovered the slightest trace of black matter in the vessels. In this way, I can readily account for the apparent conflict of statement between the authorities already adverted to and myself, on this subject. When the acid fluids holding in dissolution the grumous black blood, have lain in contact with the membrane of the stomach for a short time after death, imbibition (which is always a cadaveric phenomenon wholly different from endosmosis) takes place, transmitting the acid to the vessels of the sub-mucous tissues, where it permeates the coats of the delicate capillaries with the more ease on account of the epithelial exfoliations, which, I believe, in this disease, these tissues invariably sustain. In like manner, anatomy explains the ecchymotic, or so-called melanotic patches which are sometimes met with as *post-mortem* changes of the same surface; while in legal medicine we are taught to set high value upon similar appearances as expressive of poisoning by the different acids, such as sulphuric, oxalic, etc. (vide Christison). The primary effect of this contact of the liquid with the walls of the organ, is the darkening of the stagnant blood filling the larger capillaries, which are, doubtless, then seen meandering over the entire surface in convoluted groups, filled apparently with the same black matters that are vomited. Prolonged contact may readily increase this condition of things, until I can conceive of large patches to be formed, resembling melanotic stains or spots and surfaces which might readily have led to the supposition that sphacelation or gangrene had taken place. These may have been the conditions which induced Pyme and Peyre to imagine that they had detected sphacelus of the stomach. Dr. Physick, while giving a different interpretation to this condition of things, seems not to have recognized the real cause which produced it, nor the fact that it was but an exaggeration of that very state in which he supposed he had apprehended the black secretion in the vessels. "*I have seen,*" he says,

* This circumstance was owing to the intensity of the heat during the months of July, August and September, which made it compulsory to open the bodies so soon after death.

“the inside of the inflamed stomach as black as the black vomit, resembling it in colour exactly. This colour differs very much from the dark purple of a part in a state of gangrene, and I have never observed any putridity attending it.”*

But it may and has been objected, that no acid like that of the gastric juice exists through the rest of the alimentary canal, though the black vomit is produced along the entire tract. This is partly true. The pancreatic secretion is invariably alkaline; the contents of the small intestines have also an alkaline reaction, but it should be recollected that they become again acid in the cœcum: this is known to be lactic acid, whether we admit that it is a special secretion from the tubular glands of this part of the digestive canal, or the product of a transformation of saccharine substances in the tube. Now much, if not all the black fluid found in the upper parts of the intestines in yellow fever, has undoubtedly passed through the pylorus, undergoes a kind of digestion, and is no longer real black vomit, from what I have been able to infer from an examination of the stools; and I am persuaded that the blood of such as is formed within the intestines, sustains the acid reaction of the sulphuretted hydrogen, or the carbonic acid which is also present in the intestinal gases, which is all-sufficient to account for the transformation which ensues.

It is a fact as well established to my mind as any other in pathology, that black vomit is blood effused and acted on by the acid secretions from the surface—pure blood when it pours from the sensorial mucous membranes, black blood when issuing from the other outlets of the body with an admixture of acid. It is red, as I have frequently seen, while it oozes from the surface of the uterus, becoming darkened so soon as it combines with the vaginal secretions. It is foreign to the purpose to allude particularly to the hemorrhagic tendency in yellow fever, which declares itself by a sanguineous perspiration, if I may use such an expression, from all the mucous membranes of the body, as this well known fact will be naturally borne in mind in support of the opinion which we have expressed concerning black vomit; but I cannot omit mentioning again, what has been recorded in another part of this Journal, that is: the frequent, I may say constant, occurrence of a similar circumstance in the uterus, accompanied by large clots of blood, in the form of corpora lutea in the ovaries in every autopsy which we made, which at first induced many of my colleagues to suppose that the patients had died while menstruating. This altered blood, with the uterine secretions and epithelia, as well as the ordinary menstrual discharges, bears

a strong resemblance to the black vomit. A striking parallel may be instituted between them, for both are made up of thickened mucus, epithelia and blood corpuscles, appearing in dark grumous clotted masses; the menstrual blood, like the black vomit, was detected to be acid, never presenting the alkaline reaction of ordinary blood when procured from the vulva; and again, respecting the theories concerning them, both were regarded as secretions. That black vomit, however, is no secretion, must be evident from what has been said. It could not be detected as such in the vessels of the circulatory system, as some have supposed, for secretions are never seen in the blood-vessels of a part, not even with the aid of magnifying power. The function of secretion is the result of the vital properties of the intervacular cells, being the effect of the vital processes of these cells and their nuclei, which, during their evolution, elaborate the materials received from the blood into different products, then burst and discharge them. Nor could such a product as the black vomit be thrown out from a surface as little altered in appearance as is the mucous membrane in the majority of instances. There is, undoubtedly, diseased action going on in the stomach, which organ has been appositely termed the throne of the disease. Mucus, viscid and inspissated, is copiously elaborated, and a preternatural quantity of acid is produced; the diseased state of these products by simple contact irritates, offends and abrades the surfaces; for, as Carswell has shown, the long-continued contact of healthy gastric juice does the same. In this affection, the sub-mucous vessels become exposed, and blood is exhaled from all the pores. There can be no question that there is perverted action in the part, disturbance of function though not always of structure, and these circumstances above mentioned are its results. But what I wish to establish is, that this is not black vomit; these are but the preparatory steps towards its formation; neither the mucus, the acid, nor the disintegrated blood exists separately or combined in the vessels; there is no black vomit, such as we recognize it out of the body, in these vessels, but the several ingredients are united and combined chemically after they have been separately produced. This, therefore, accounts for the frequent absence of all apparent lesions in the stomach and intestines; for the formation of black vomit is perfectly compatible with mere functional derangement: it does not by any means imply organic lesion, without which destruction of the tissues themselves to a considerable extent, it could not exist as a secretion; for I believe that a *secretion* of such appearances as the vomit, would plainly betoken a state of disease reaching even unto sphacelation. The sanguine

neous exhalation which occurs, and which is often nothing but a transudation of hematine through the coats of the vessels, I believe is the result of attrition of the mucous surface denuded of its epithelia, coupled with an altered state of the blood, which renders it through its fluidity very liable to transude the tunics of vessels. This hemorrhage supervenes during the latter periods of the disease, as expressive of a want of vital tonicity on the part of the tissues and their blood-vessels; and when all the vital energies of the system are in abeyance this may occur, and the hematine of the blood, and, perhaps, sometimes even the blood discs themselves, in no very great numbers however, may pass out without any *perceptible* change in the structure of the membrane but a thickening, with abrasion of the coats of the smaller capillaries, which, indeed, is often met with, and is somewhat similar to that noticed during menstruation.

Such being the simple nature and history of one of the characteristic symptoms of yellow fever, it may be asked, perhaps, why is it justly regarded as so fatal in its results? It is certainly not the quantity of blood lost which renders the event thus dangerous, any more than it is the amount of blood lost by rupture of the heart, when the pericardium is uninjured, that induces sudden death. Here the vital fluid is retained within an inextensible fibro-serous membrane, until by accumulation it presses with fatal power upon the great centre of circulation, whose action is soon mechanically arrested; so in the instance before us, it is not the proportion of blood consumed in forming the black vomit which constitutes it mortal, but rather the relation of the altered fluid to the tissues, causing and explaining the ready extravasation or hemorrhagic tendency.

We may conclude, therefore, from what precedes,

1st. That the microscope has furnished decisive proof of the nature of that black matter formed within the entire length of the digestive canal; showing that it is blood chemically altered by the action of acids wherever it is seen, whether in or out of the vessels—the acids being hydrochloric when derived from the stomach, sulphuric acid of the sulphuretted hydrogen, or carbonic and lactic acids, when obtained throughout the remaining portions of the canal.

2d. That the pasty and figured stools are composed of the black matters which have lost all of their characteristic features but the colour, having undergone a process of digestion.

3d. That no animalculæ are discoverable in either fresh or putrescent black vomit, but as it decomposes certain fungi are disclosed, which

are most frequently, if not always, developed outside of the body, depending upon, though not the cause of, fermentation.

4th. That the artificial black matter produced by the addition of an acid to blood, is in every respect analogous to true black vomit, being both physically, chemically and microscopically identical.

Since the execution of the accompanying plate, and since handing in this paper for publication, my attention has been directed to two printed notices on the same subject, the incorporation of which in this article may add to its usefulness and completeness as a microscopical account of black vomit. In the November number for 1852, of the N. O. Med. and Surg. Journal, Dr. Riddell, at the request of the editor, gives a brief transcript of his examination of the ejecta of several yellow fever patients; and in the Lancet for February, 1853, Dr. Hassal reports to Messrs. Wiblin and Harvey, the result of his observation of one sample of the vomit, which they forwarded him from Southampton. I am glad to find that these gentlemen have corroborated in many particulars, the observations made in 1849, and those which, during the past summer, we were making simultaneously.

Both of these observers agree with me as to the absence of animalculæ, which, as Dr. Hassal remarks, could hardly be developed in a liquid so very acid, "except as the result of decomposition." This is precisely the remark which I made a few years ago in another number of this Journal, taking very minute particles in movement in putrescent black vomit for the smallest forms of animalculæ, developed, as I then thought, during decomposition; which were, perhaps, certain algoid bodies such as Dr. Riddell has recently described as possessed of oscillatory motion; but it is necessary to remark, that during the past season, while examining the many samples at my command, I never could detect the slightest motion of any kind, nor has Dr. Hassal been any more successful. The black vomit, from its intense acidity, is, perhaps, not so favourable to the development of algæ as of fungi, for which it is particularly fitted, being both an acid and organic product. Varied circumstances, doubtless, influence the kinds of fungi that are produced, and different varieties will probably present themselves to each subsequent individual who may chance to examine this subject. The *torula* seems to me to be the most constant, though, perhaps, not a specific product of black vomit. The ramous branches of the sporules of a fungus, to which Dr. Hassal refers, seems to me nothing more than the beaded cells of the *torula* I have described. That different fungi are evolved under particular circumstances, is shown by the fact, that we have all seen different growths. Dr. Riddell noticed,

among other things, a species of *sarcina*; and Dr. Hassal, circular spores with filaments, and branched and moniliform threads of a fungus. By Dr. Hassal, more weight is assigned the presence of these fungi than I am disposed to acknowledge, when he supposes they become "*important agents in keeping up the obstinate sickness which is so distressing a symptom of yellow fever.*" Indeed, he is so preoccupied with the development of these adventitious growths, that nothing is told us of the real nature of the vomit. He appears not to have seen, or to have wholly neglected mentioning, the separate ingredients; but I cannot look upon these developments as the cause of the epigastric symptoms. Epigastric tenderness and irritability of stomach commence very early in yellow fever—long prior to the formation of black vomit; and these are sometimes continued until death occurs, without the patient having vomited, and when the stomach contained no black matters, and consequently no fungi of any kind. When vomiting sets in, it is continued frequently until the fatal termination ensues without the production of black vomit; and this fluid is sometimes again found in the stomach after death, when no vomiting has occurred during the attack. Moreover, from my observations I should say, that fungi are developed after the matters have been ejected—at least I have not discovered fungi in the liquids taken directly from the stomach. It is true, that in certain cases of dyspepsia, accompanied by the ejection of fermented matters, the vomiting appears to be produced by the formation of a parasitic organism, which Dr. Goodsir was the first to detect in 1843, and from its fancied resemblance to a wool-pack, to describe under the appellation of *sarcina ventriculi*. He believes that the *sarcina*, by multiplying fissiparously, produces a fermentation similar to that in yeast, which distresses and irritates the stomach, keeping up the vomiting. I am disposed to think, that the *sarcina* is as frequently developed without as within the stomach, or, at least, the spores of the fungus are perhaps received from without, and are only placed in more favourable conditions for fructifying when within the fermenting liquids of the stomach. This view is justified by Dr. J. H. Bennett's* observations, as he informs us that on the matters which dyspeptic patients occasionally vomit, "there gathers, after a short time, a thick brownish scum, exactly resembling yeast. On examining this scum with the microscope, it is found to contain a large number of *sarcina ventriculi*, mingled with starch corpuscles, more or less broken down, and granular matter." This opinion finds additional support

* Monthly Journal of Med. Science, Feb., 1853; and Amer. Jour. Med. Sc. April, 1853, p. 461.

from the fact also ascertained, that certain kinds of diet, particularly farinaceous articles of food—such as oatmeal, especially in the form of porridge—produces them in the greatest quantity. I am very much of opinion, that all these varieties of vegetation, should they ever appear already developed in fresh ejecta of yellow fever, would be referable to similar substances administered in drinks to patients, such as gruel, arrow-root, etc. If we met invariably with the same fungus in black vomit, I might acknowledge the pertinency of Dr. Hassal's suggestion; for some have supposed that fungi are developed and that their sporules do originate within the human body—such as the *sarcina vesicæ*, which Dr. Bennett found in the urine, and which may have been formed in the bladder. Virchow has detected a fungus in a pulmonary abscess, and filamentous forms are seen in cutaneous diseases, such as *Porrigio favosa* and *Sycosis menti*; and again in Aphthous ulcers on mucous surfaces, as in the *trush* of children; but it is probably the diseased condition of the secretions or fluids which fructifies the germs, and not the sporules themselves which produce the morbid state.

I see that Dr. Hassal has encountered the same difficulty which I at first met with respecting certain bodies to which he alludes at No. 5, letter *e*. These are the oval corpuscles, which I have stated above as having very much embarrassed me in determining their nature. Perhaps I am right in the opinion already expressed, that they are the nuclei of epithelia which have been broken down, and the cell dissolved.

I cannot better terminate this paper than by transcribing the note of Dr. Hassal as it appears in the *Lancet*. With an eighth of an inch object glass, he detected—

1st. Ramose branches of the sporules of a fungus (*a*).

2d. Large circular sporules, usually single, but sometimes ranged in rows, and giving origin to slender threads or filaments (*b*).

3d. Branched and moniliform threads of a fungus, usually occurring in bunches (*c*).

4th. Many compound cells, having the appearance of sporangia (*d*).

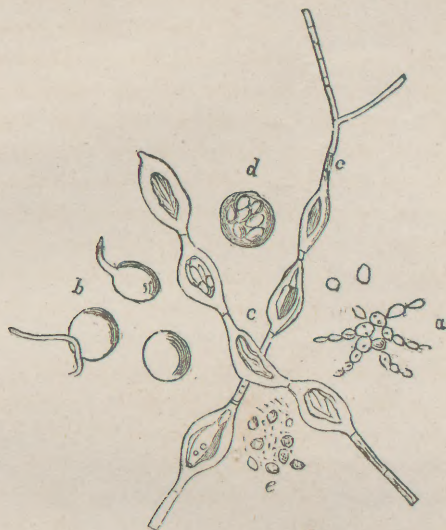
5th. Vast numbers of irregular bodies, frequently of a brown colour, and resembling somewhat blood discs, shrivelled and discoloured, but insoluble in acetic acid (*e*).

6th. Multitudes of molecules and amorphous masses of a brownish or blackish colour.

7th. Starch corpuscles and hairs, forming the down of wheat.

There were no animalcules of any kind, nor, from the acid character

of the liquid, was it likely that any would be present, except as the result of decomposition. The sporules and threads *a*, *b*, *c*, probably all represent different stages in the growth of the same fungus. This is certainly the case with *b* and *c*. This fungus is different from any



with which I am acquainted as occurring in the blood of the human subject, and it is very possible that its development may have taken place subsequent to the ejection of the liquid.

I regret that I have not been able to determine positively the nature of the bodies resembling altered blood corpuscles, and which formed the most abundant and peculiar element of the fluid, and upon which its colour, to some extent, depended. It is possible that they are the sporules of a fungus; at all events, their insolubility in strong acetic acid, is opposed to the opinion that they are altered blood discs. Supposing the fluid, while in the stomach, really to contain the sporules of a fungus, which is very probable, then there is much reason to believe that they would be important agents in keeping up the obstinate sickness which is so distressing a symptom of yellow fever. That the sporules of the fungus *sarcina ventriculi*, do really give rise to vomiting, is certain; and with a view to check the sickness, I would recommend the treatment which has been found so surprisingly efficacious in cases of *sarcina*, viz, the systematic administration of alkalies, with especially

repeated doses of sulphite of soda. An acid liquid is one of the conditions essential to the development of most fungi. By the exhibition of alkaline remedies, this condition is destroyed, while the sulphur of the sulphite would exert a most destructive effect upon the sporules of any fungus which might be present.

